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$$= t \tan\phi \left\{ (1-\sin^2\phi)^{\frac{1}{2}} - \frac{1-\sin^2\phi}{\mu}\left(1-\frac{\sin^2\phi}{\mu^2}\right)^{\frac{1}{2}} \right\}$$

$$= t \tan\phi \left\{ 1 - \frac{\sin^2\phi}{2} - \frac{\sin^4\phi}{8} - \frac{\sin^6\phi}{16} \quad . \quad . \quad . \right.$$

$$\left. - \frac{1-\sin^2\phi}{\mu}\left(1 + \tfrac{1}{2}\frac{\sin^2\phi}{\mu^2} + \tfrac{3}{8}\frac{\sin^4\phi}{\mu^4} + \tfrac{5}{16}\frac{\sin^6\phi}{\mu^6} + \right) \right\}$$

$$= t \tan\phi \left\{ \frac{\mu-1}{\mu} - \sin^2\phi\left(\frac{1}{2} - \frac{1}{\mu} + \frac{1}{2\mu^3}\right) \right.$$

$$- \sin^4\phi\left(\frac{1}{8} - \frac{1}{2\mu^3} + \frac{3}{8\mu^5}\right)$$

$$- \sin^6\phi\left(\frac{1}{16} - \frac{3}{8\mu^5} + \frac{5}{16\mu^7}\right)$$

$$\left. - \&c. \right\}$$

Taking $\mu = \frac{3}{2}$ and $\phi$ successively 5°, 10°, and 20°, then approximately

$$s = \frac{t}{3} \tan 5^\circ (1 - \cdot 00042)$$

$$s = \frac{t}{3} \tan 10^\circ (1 - \cdot 00156)$$

$$s = \frac{t}{3} \tan 20^\circ (1 - \cdot 00529).$$

## *The Lunar Eclipse,* 1892 *May* 11: *Observations made at Mr. Crossley's Observatory, Bermerside, Halifax.* By Edward Crossley, M.P., and Joseph Gledhill.

The weather here on the 11th was all that could be desired—a cloudless day and night. Owing, however, to the low position of the Moon (altitude about 18° when on the meridian) the naked-eye and other phenomena were not well seen before 10 o'clock. But as the Moon got higher the spectacle was very fine: the eclipsed portion was seen to be of a clear ruddy tinge, and the principal lunar seas, &c., were readily seen and identified with the help of an opera-glass. This beautiful colour disappeared about midnight, and gave place to a dull grey tinge.

While watching for the occultations of the stars given in the *Observatory* for May, an attempt was made to note the times when the general curve of the dark shadow reached some of the best-known craters.

The instrument used throughout the observations was the $9\frac{1}{3}$-inch Cooke refractor, power 66.

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Before mid-eclipse :—

| | | | | G.M.T. | |
|---|---|---|---|---|---|
| | | | h | m | s |
| Aristarchus, | 1st | edge of crater | 9 | 18 | 16 |
| Kepler, | ,, | ,, | | 25 | 27 |
| Copernicus, | ,, | ,, | | 32 | 36 |
| ,, | 2nd | ,, | | 33 | 30 |
| Plato, | 1st | ,, | | 33 | 0 |
| ,, | middle | ,, | | 34 | 0 |
| Archimedes, | 1st edge | ,, | | 37 | 0 |
| ,, | middle | ,, | | 38 | 2 |
| ,, | 2nd edge | ,, | | 38 | 30 |
| Aristotle, | 1st | ,, | | 43 | 7 |
| Eudoxus, | ,, | ,, | | 43 | 45 |
| Aristotle, | 2nd | ,, | | 44 | 30 |
| Eudoxus, | ,, | ,, | | 45 | 15 |
| Linné, | | | | 46 | 30 |
| Menelaus, | | | | 53 | 30 |
| Bessel, | | | | 51 | 24 |
| Tycho, | 1st | ,, | 10 | 8 | 38 |
| ,, | 2nd | ,, | | 12 | 23 |
| Proclus, | | | | 8 | 15 |

After mid-eclipse :—

| | | h | m | s |
|---|---|---|---|---|
| Aristarchus, | | 11 | 49 | 22 |
| Copernicus, | 1st edge | | 53 | 22 |
| ,, | middle of crater | | 54 | 27 |
| ,, | 2nd edge of crater | | 55 | 29 |
| Proclus, | | 12 | 26 | 28 |

## *Occultations.*

Careful watch was kept on the sky near the advancing limb of the Moon, but no stars could be seen until about 10 o'clock. Several very faint ones were seen as the time went on, but they could not be seen when close to the Moon's limb. The following observations were made: the earlier ones by Mr. Crossley at the telescope and a friend at the chronometer; after 11 o'clock I took charge of both instruments.

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| Time. | Phenomena. | Angle. | G.M.T. Observed Time. | Remarks. |
|---|---|---|---|---|
| h m | | ° | h m s | |
| 9 45 | D | 142 | ... | No star seen near limb. |
| 49 | D | 65 | | |
| 10 16 | D | 112 | 10 15 26 | |
| 20 | D | 94 | 10 19 32 | |
| 26 | R | 355 | ... | Not seen until a little way from limb. |
| 33 | D | 90 | 10 33 47 | |
| 43 | D | 103 | 10 40 51 | Perhaps 1 sec. too late. |
| 58 | R | 281 | ... | Faint star; not seen till away from limb. |
| 11 0 | D | 57 | ... | Faint star; not seen till away from limb. |
| 12 | D | 109 | ... | Faint star; not seen till away from limb. |
| 31 | R | 327 | 11 28 34 | |
| 34 | R | 309 | 11 31 6 | |
| 42 | R | 332 | 11 39 35 | |
| 43 | R | 8 | 11 43 57 | Very faint. |
| 59 | R | 317 | ... | A bright star; lost owing to interruption. |
| 12 31 | R | 306 | 12 28 15 | Not seen double; examined it with 240. |

The times of the occultation phenomena were taken to the nearest second. With regard to the times when the dark edge of the shadow touched a crater-wall, &c., they also were taken from the chronometer—i.e., when the shadow appeared just to touch a wall the chronometer time was recorded.

*Bermerside, Halifax:*
1892 *May* 13.

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## *Occultations of Stars by the Eclipsed Moon,* 1892 *May* 11, *and other Phenomena,* observed by the Rev. A. Freeman, M.A.

The stars are those of the list published in the *Observatory* of 1892 May. The telescope employed was my 6½-inch refractor, with an eyepiece having a power of 35 and a field of 1° 8′ in diameter. The time is dependent on comparisons of a solar chronometer with a trustworthy electric time-signal, May 4 and May 12, showing a daily gaining rate of only $0^{\mathrm{s}}{\cdot}14$ in the interval.

| B.D. −19°. | Magn. | Occ. | G.M.T. | Remarks. |
|---|---|---|---|---|
| | | | h m s | |
| 4091 | 8·3 | D. | 10 17 25·25 | Sudden. |
| 4095 | 8·9 | D. | 10 35 51·25 | Sudden. |
| 4087 | 9·7 | R. | 11 3 4·25 | Late.* |
| 4099 | 8·2 | D. | 11 14 18·25 | Final.† |
| 4091 | 8·3 | R. | 11 35 2·25 | Sudden. |
| 4095 | 8·9 | R. | 11 44 14·25 | Late.‡ |
| 4097 | 9·4 | R. | 11 48 9·25 | Late.* |

*Phenomena of the Shadow.*

| h m | |
|---|---|
| 9 11·4 | Moon has entered shadow (late). |
| 9 17·4 | Shadow bisects Aristarchus. |
| 9 31·4 | Shadow touches Copernicus ring on E. |
| 9 32·9 | Shadow touches Mersenius on E. |
| 9 34·0 | Shadow covers Mersenius. |
| 9 34·8 | Shadow touches Copernicus ring on W. |
| 10 9·2 | Shadow touches Tycho ellipse on E. |
| 10 11·1 | Shadow bisects Tycho. |
| 10 12·5 | Shadow touches Tycho ellipse on W. |
| 11 20·9 | Shadow touches Tycho on S. |
| 11 22·4 | Shadow bisects Tycho. |
| 11 24·0 | Shadow touches Tycho on N. |
| 12 37·5 | Moon has left shadow (late). |

There was a certain amount of haze about throughout the eclipse, varying in density but without cloud. The haze became

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* Star first seen 22″·3 off limb of ☽ (= half greater axis of Tycho).

† This double star hung on the limb for two or three seconds.

‡ Star first seen 8″·2 off limb of ☽ (= quarter least axis of Tycho).